1. SUMMARY

The Department of Energy (DOE) has recently decided to construct and operate a Defense Waste Processing Facility (DWPF) at the Savannah River Plant (SRP) to immobilize the high-level radioactive waste generated and stored pending disposal in a federal geologic repository. The Savannah River Plant is a major installation of DOE for producing nuclear materials for national defense. About 110,000 m^3 (28 million gallons) of high-level waste are now in storage in underground tanks at SRP*. The immobilized waste from the DWPF will be the initial barrier of the proposed multibarrier engineered and geologic system for disposal of high-level waste. Based on the recently completed waste form screening program, DOE has the necessary data to select the waste form for the DWPF. The purpose of this document is to assess the potential environmental consequences of selecting borosilicate glass as the immobilization form for high-level waste at SRP.

In the immobilization process the high-activity fraction of the SRP high-level waste is mixed with glass frit to form the feed for the melter. The glass is cast from an electric-heated, ceramic-lined melter into canisters 0.61 m in diameter and 3.0 m high. The molten glass solidifies into a chemically inert, highly insoluble, nondispersible, nonvolatile solid with very low measured leachabilities in simulated groundwater. Thermal stability and structural stability against self-irradiation effects of the glass form are fully sufficient to maintain waste form integrity. Key properties of the borosilicate glass waste form are shown in Table 1-1.

The borosilicate glass form, within the proposed multibarrier waste disposal system, contributes to the isolation of the waste from the accessible human environment. Borosilicate glass has sufficient mechanical strength and impact resistance to resist the stresses of repository emplacement (and retrieval during a specified retrieval period). It is compatible with a full range of repository geologies, and has projected (fractional) release rates into repository groundwaters of less than 1 part in 10,000 per year, as required by proposed DOE waste form specifications.

---

* The waste is composed of insoluble sludge, precipitated salts, and supernatant (liquid). The actual volumes at any time in the future will be a function of the waste generation from plant operations, DWPF startup, and the operations of processes to concentrate the waste.

TABLE 1-1

Key Properties and Characteristics of Borosilicate Glass Waste Form

Property or Characteristic	Borosilicate Glass
Density, g/cm^3	2.75
Waste Loading, wt %	28
Toleration of Waste Variability	Acceptable
Long-Term Leachability,* $g/m^2 \cdot d$	10^{-3} to 10^{-4}
Fractional Release Rate from Full-Size Form,** yr^{-1}	10^{-5} to 10^{-6}
Radiation Stability	Very good
Impact Response,† wt % fines	0.14 to 0.18
Processability††	Relatively simple

* Based on plutonium leach rates in long-term tests at room temperature.

** Estimated from plutonium leaching data (conservatively assumes that release of radionuclides is not reduced by solubility limitations).

† Generation of particles less than 10 micrometers in size from single impact of 10 J/cm^3 energy density.

†† Relative ease of producing the waste form.

Calculated doses and health effects from emplaced waste in potential repositories during the isolation period are small and are not significantly influenced by any reductions in leachability below current values for the borosilicate glass. Under most circumstances, peak doses are calculated to be less than 1% of the dose from natural background. For a typical repository, credible events which might damage the repository and its emplaced waste would not significantly affect this dose. The low solubilities of many of the radionuclides and their sorption on engineered barriers and on the surrounding rock should significantly reduce the release rates below those predicted from the leach tests and used in the repository consequence analysis.

Crystalline ceramic,* the leading alternative to borosilicate glass, also appears to be an acceptable form for immobilizing the SRP high-level waste. Both are expected to meet regulations and repository acceptance criteria. The assessment also shows that the environmental effects of disposing of SRP high-level waste as a crystalline ceramic form would not differ significantly from the projected effects for disposal of the borosilicate glass form. A comprehensive evaluation program led to the recommendation of borosilicate glass as the preferred waste form because process complexity, development requirements, and programmatic costs were determined to be less for borosilicate glass than for crystalline ceramic. The utilization of the borosilicate glass is supported by waste form evaluation programs in other countries in which essentially all other nations now reprocessing or planning to reprocess spent nuclear fuels are either using borosilicate glass or have selected borosilicate glass as the preferred high-level waste form.

---

* Crystalline ceramic is a generic term for a product of compatible mineral phases, formed at high temperatures. Two candidate waste forms, Synroc-D (a titanate-based ceramic developed by Lawrence Livermore National Laboratory) and tailored ceramic (an alumina/rare earth-based ceramic developed by Rockwell International), are included in this term.